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78. (New) The semiconductor laser of Claim 49, wherein the active layer is configured to generate light along at least 1000 microns of the length of the cavity.

79. (New) The method of Claim 57, wherein the active layer is configured to generate light along at least 1000 microns of the length of the cavity.

80. (New) The method of Claim 65, wherein the active layer is configured to generate light along at least 1000 microns of the length of the cavity.

### REMARKS

The above amendments are made in response to the first Office Action mailed November 6, 2002, wherein:

1. Claims 1-72 were rejected under 35 U.S.C. § 112, second paragraph, on the basis of Claims 1, 2, 9, 17, 25, 29, 30, 34, 36, 37, 39, 41, 49, and 57 being indefinite;
2. Claims 1-5, 9-13, 17-21, 25, and 29-40 were rejected under 35 U.S.C. § 102(a) as being anticipated by U.S. Patent No. 6,174,748 to Jeon, *et al.*, (the "Jeon patent");
3. Claims 6-8, 14-16, 22-24, and 26-28 were rejected under 35 U.S.C. § 103(a) as being obvious over the Jeon patent in view of U.S. Patent No. 5,993,073 to Hamakawa, *et al.*, (the "Hamakawa patent"); and
4. Claims 41-72 were rejected under 35 U.S.C. § 103(a) as being obvious over the Jeon Patent in view of the U.S. Patent Nos. 6,249,748 (Itoh, *et al.*) and 6,343,088 (Mugino *et al.*).

With this Amendment, Claims 1-30 and 36-38 have been canceled without prejudice, and independent Claims 31, 33, 39, 41, 49, 57 and 65 have been amended to address the rejections under § 112. A proposed drawing amendment to FIG. 1 is attached to address the objection noted by the Examiner. Applicants respectfully thank the Examiner for noting the error and providing a suggested correction to FIG. 1, which has been adopted. Below, Applicants provide reasons as to why the pending claims, as amended, are allowable over the cited prior art. New Claims 73-80 have been added. **Claims 31-35, 39-72 and new Claims 73-80 are pending in the application.**

### **Response to the Rejection of the Claims 1-72 under 35 U.S.C. § 112, Second Paragraph**

Claims 1-30 and 36-38 have been cancelled without prejudice. The remaining claims have been amended to address the Examiner's points. Specifically, the descriptions of the "relationships" recited by the claims have been more clearly stated, the recitations of open-ended ranges have been removed, and the structural relationships between claim elements have been clarified. In addition, the condensed phrases of the original claims have been expanded into long format for clarity. These clarifying amendments are supported by the original claims. In addition, Applicants indicate the support in the application for these particular amendments:

1. The first paragraphs of method Claims 31, 33, and 39 have been amended to indicate that the fabrication method is for a semiconductor laser apparatus which is to be operated at a desired optical output power level from a source of electric drive power. The feature of fabricating the laser device for operation of the laser device at a desired optical output power level is disclosed at many locations in the specification, including: page 1, lines 5-8; page 3, lines 15-18 and 29-30; and page 38, line 4 through page 39, line 21. For example, the recitation of: "for optical output power to be constant as a parameter" at page 3, lines 29-30 supports the recitation in the claims of: "to be operated at a desired optical output power level."
2. In order to clarify the purpose of the last two paragraphs of apparatus Claims 41 and 49 (as provided above), the fifth paragraphs of these claims have been amended to indicate that the output power level  $P_{OUT}$  is maintained within a range that is less than or equal to the specified upper bound and greater than or equal to the specified lower bound. This amendment is clarifying in nature, is supported by original Claims 41 and 49, and does not enter new matter.
3. The first paragraphs of method Claims 31, 33, 39, 57, and 65 (as provided above), and the second paragraphs of apparatus claims 41 and 49 (as provided above) have been amended to recite that the apparatus comprises a semiconductor laminated structure which includes a substrate, a lower cladding layer, an upper cladding layer, an active layer disposed between the cladding layers, and front and back facets. In addition, the active layer is configured to generate light such that the apparatus provides optical output power at the front facet in response to the source of electric drive power. The semiconductor laminated structure is shown in FIGS. 1-3 of the

present Application, and described in the present Specification from page 15, line 9 through page 16, line 12.

4. The second paragraph of Claim 31 recites the step of acquiring a relationship of the electric drive power as a function of the cavity length and the optical output power level of the semiconductor laser apparatus. Such an exemplary relationship is shown graphically in FIG. 8 of the present Application, and described by the present Specification at page 20, line 22 through page 21, line 19. In FIG. 8, the electric drive power (Y-axis) is shown as a function of cavity length (X-axis) and optical output power (parameterization lines). It is well established in U.S. patent law that amendments to the claims may be supported by original drawings of the application (see, for example, *In Re Reynolds*, 170 U.S.P.Q. 97 (C.C.P.A. 1971) and *Ex parte Horton*, 226 U.S.P.Q. 697 (P.T.O. Bd. App. I. 1985)).
5. The second paragraph of Claim 33 recites the step of acquiring a relationship of the photoelectric conversion efficiency as a function of the cavity length and the optical output power level of the semiconductor laser apparatus. Such an exemplary relationship is shown graphically in FIG. 6 of the present Application, and described by the present Specification at page 18, line 22 through page 19, line 20. In FIG. 6, the photoelectric conversion efficiency (Y-axis) is shown as a function of cavity length (X-axis) and optical output power (parameterization lines).
6. The second paragraph of Claim 39 recites the step of acquiring a relationship of the electric drive power as a function of the impurity carrier concentration of the upper cladding layer. A supporting relationship for this is shown graphically in FIG. 10 of the present Application, and described by the present Specification at page 22, line 17 through page 23, line 23. In FIG. 10, the electric drive current (Y-axis) is shown as a function of carrier concentration (X-axis), optical output power (one set of parameterization lines), and cavity length (another set of parameterization lines). The relationship shown in FIG. 10 includes more parameterization than needed to support the relationship recited by Claim 39.
7. The last two paragraphs of each of Claims 31, 33, and 39 have been rephrased to clarify the language, and to clearly state that a specific *value* of cavity length (Claims 31 and 33) or impurity carrier concentration (Claim 39) is determined from

the relationship acquired by the prior claim step. These amendments are supported throughout the present Specification, and in particular by the "Summary of the Invention" Section where it is indicated that "a respective element *value* of the semiconductor laser apparatus is determined on the basis of relationships between respective elements of the semiconductor laser apparatus including a cavity length of the semiconductor laser apparatus and a carrier concentration of an upper cladding layer of the semiconductor laser apparatus and a photoelectric conversion efficiency or electric drive power of the semiconductor laser apparatus..." (emphasis added; see page 3, lines 23-29 of the present Specification).

8. The second paragraphs of Claims 41 and 49 (as provided above), and the first paragraph of Claim 57, have been amended to change 900  $\mu\text{m}$  to 1000  $\mu\text{m}$  to match the use of 1000  $\mu\text{m}$  in the last two paragraphs of these three claims. Support for the amendment is provided by the claims themselves in their last paragraphs.
9. The preamble of method Claim 65 has been condensed to more clearly focus on the subject matter that the claim is directed to. Related to this, the preamble of Claim 57 has been amended to adopt a portion of the preamble of Claim 65.

The language of dependent Claim 34 has been clarified. The amendments are supported by depiction of expression L1 in FIG. 6, and the description thereof at page 19, line 29 through page 20, line 7 of the Specification. As described in this section of the Specification, expression L1 is obtained from the acquired relationship illustrated by FIG. 6, and expression L1 is a relationship between cavity length and optical output power which describes combinations of cavity lengths and optical output power levels that make the photoelectric conversion efficiency maximal.

The Rejection of Claim 57 noted that the original preamble of the claim and the body of the claim had recited the same acts: "a method of operating a semiconductor laser ..., comprising: operating the semiconductor laser..." (emphasis added). The Rejection indicated that this language was in error because it was in narrative form, and indicated that the body of the claim would have to be rewritten in means-plus-function language in order to be given patentable weight. Instead, Applicants have addressed the duplication of actions by amending the preamble of the claim to indicate that the method is directed to "increasing the photoelectric conversion efficiency of a semiconductor laser..." This amended language follows the

preamble language of Claim 65. Support for this amendment to Claim 57 is provided by original Claim 65, and numerous other places in the present Specification (e.g., page 2, lines 16-22). With this preamble context, the original body of Claim 57 sets forth a tangible, non-functional act which promotes an increase in photoelectric conversion efficiency. This tangible act is the step of operating the laser at an optical output power level  $P_{OUT}$  which is within a specific range that depends upon the cavity length  $L$  of the semiconductor laser. The upper and lower bounds of the range are specified as respective functions of the cavity length  $L$  by the last two paragraphs of the claim. The lower bound for  $L$  recited by Claim 57 is shown by line segments 541-545 of FIG. 16, and the upper bound is shown by line segments 546-550. The range of optical output power level within the upper and lower bounds recited by Claim 57 has been discovered by the Applicants to promote increased photoelectric conversion efficiencies for the range of cavity lengths  $L$  indicated by the claim.

The Rejection of Claim 57 has suggested that the body of claim be rewritten in means-plus-function language, as defined by the sixth paragraph of 35 U.S.C. § 112. This paragraph states that "[a]n element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof" (emphasis added). The sixth paragraph does not set out a mandatory requirement that a function or a functional element of a claim be written as a means or step for performing a function. Rather, the sixth paragraph sets out an optional shorthand format which allows an applicant to recite an element in the body of a claim in terms of the element's function without having to recite the structure, materials, and/or acts of the element.

As to pending Claim 57, the element which has been rejected already recites a tangible act based on a tangible device structure, as described above. Accordingly, Applicants respectfully submit that the shorthand format permitted by the sixth paragraph of § 112 is not applicable to the body of Claim 57.

The Rejection of Claim 57 relied in part upon the 1929 case of *In re Fuller* (1929 C.D. 172; 388 O.G. 279), which was cited in section 706.03(c) of old editions of the M.P.E.P. from the 1970s. The *In re Fuller* case was issued before "means-plus-function" language was enabled by the 1952 patent act. The *In re Fuller* case is no longer cited by the current edition of the

M.P.E.P. As with many of the court cases issued prior to 1952, the *In re Fuller* case did not distinguish between language that expressed functional relationships (now called functional language) and language that merely expressed the advantage or benefit of an invention. The old editions of the M.P.E.P. also did not clearly distinguish between these two types of language. The current and recent editions of the M.P.E.P. more clearly distinguish between the two types of language. The obsolete section 706.03(c) of the old M.P.E.P. editions and the *In re Fuller* case pointed to the following claim as being objectionable: "A woolen cloth having a tendency to wear rough rather than smooth." The body of this claim ("a tendency to wear rough rather than smooth") only expressed the advantage of the claim, and did not express any specific structure or acts that led to the achievement of the advantage. This claim is different from present Claim 57. Present Claim 57 recites a specific act based on a specific device structure (e.g., cavity length L) that leads to the advantage of improving the photoelectric conversion efficiency of the device. Unlike the claim in the *In Re Fuller* case, the *body* of present Claim 57 does not merely recite the advantage of the claim. The *preamble* of present Claim 57 does recite the advantageous effect of the claim, but it is permissible under U.S. law for a claim's *preamble* to make such a recitation.

For the above reasons, and with the above amendments, Applicants respectfully submit that amended Claim 57 meets the requirements of 35 U.S.C. § 112, and respectfully request that the rejection be withdrawn. Should the rejection based on *In Re Fuller* be maintained, Applicants respectfully request that the Examiner provide Applicants with a citation to the M.P.E.P. or other PTO document which explains the Office's view and application of the *In Re Fuller* case. This will assist Applicants in better addressing the rejection, if maintained.

#### **Response to the Rejection of Claims 31-35 and 39-40**

Claims 31-35 and 39-40 were rejected under 35 U.S.C. § 102(a) as being anticipated by the Jeon patent. The independent claims within this group are Claims 31, 33, and 39. The Jeon patent is directed to making a vertical taper in the active layer of a laser device, at one end of the laser in order to adiabatically convert the elliptical shape of the laser beam to a more circular shape (see the Abstract, FIGS. 3C-3E and 4B-4E, and column 4, lines 11-22 of the Jeon patent). The Jeon patent does not teach or suggest a step of acquiring a relationship of electric drive power as a function of cavity length and optical output power level, which is recited by present independent Claim 31, and included by its dependent Claim 32. The Jeon patent also does not teach or suggest a step of acquiring a relationship of photoelectric conversion efficiency as a

function of cavity length and optical output power level, which is recited by present independent Claim 33, and included by its dependent Claims 34-35. The Jeon patent also does not teach or suggest a step of acquiring a relationship of electric drive power as a function of the impurity carrier concentration of the upper cladding layer and the optical output power level of the semiconductor laser apparatus, which is recited by present independent Claim 39, and included by its dependent Claim 40.

In addition, the Jeon patent does not teach or suggest a step of determining a value of the cavity length from the acquired relationship such that the electric drive power is vicinal to a minimum for the desired optical output power level, or a step of forming the semiconductor laser apparatus with this determined value of cavity length, which are steps recited by independent Claim 31. The Jeon patent also does not teach or suggest a step of determining a value of the cavity length from the acquired relationship such that the photoelectric conversion efficiency is vicinal to a maximum for the desired optical output power level, or a step of forming the semiconductor laser apparatus with this determined value of cavity length, which are steps recited by independent Claim 33. The Jeon patent also does not teach or suggest a step of determining a value of the impurity carrier concentration from the acquired relationship such that the electric drive power is vicinal to a minimum for the desired optical output power level, or a step of forming the semiconductor laser apparatus with this determined value of impurity carrier concentration, which are steps recited by independent Claim 39.

Therefore, the Jeon patent fails to teach or suggest at least two steps of the independent Claims 31, 33, and 39, and therefore the Jeon patent cannot anticipate Claims 31-35 and 39-40 under U.S. patent law.

The Rejection of these claims has noted a specific single value of electrical-to-optical conversion efficiency at column 11, lines 35-41 of the Jeon patent. However, this single stated value does not, and cannot, imply the teaching of any of the above-noted steps. In addition, the specific single value is for a device with a cavity length which is not within the ranges recited by independent Claims 31 and 33.

For these reasons, Applicants respectfully submit that the Jeon patent fails to teach or suggest all the steps of independent Claims 31, 33, and 39, and that these independent claims and their dependent claims are novel and non-obvious over the Jeon patent. Accordingly, Applicants respectfully request that this Rejection of Claims 31-35 and 39-40 be withdrawn.

## Response to the Rejection of Claims 41-72

Claims 41-72 were rejected under 35 U.S.C. § 103(a) as being obvious over the Jeon Patent in view of U.S. Patent Nos. 6,249,748 (Itoh, *et al.*) and 6,343,088 (Mugino, *et al.*). The independent claims within this group are Claims 41, 49, 57, and 65. M.P.E.P. § 706.02(j) states the three basic requirements for establishing a *prime facie* case of nonobviousness:

“[t]o establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant’s disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).”

If any one of the three criteria is not present, the *prime facie* case fails. Below, Applicants show that the patents to Jeon, Itoh, and Mugino, as a group, fail to teach all of the claim limitations of independent Claims 41, 49, 57, and 65.

Each of independent Claims 41, 49, 57, and 65 specifies certain combinations of cavity length L and operating optical output power level P<sub>OUT</sub>, as shown by the enclosed area of FIG. 16 of the present application. The Jeon patent does not disclose a combination of cavity length and optical output power level which falls within this area. The only power levels disclosed by the Jeon patent are for devices which have cavity lengths of 750  $\mu\text{m}$ . Jeon does not disclose any operating power level for a cavity length of 1000  $\mu\text{m}$  or more. Moreover, neither of the Itoh and Mugino patents discloses cavity lengths greater than 800  $\mu\text{m}$ . Accordingly, since the combination of the three references cited by the Rejection does not have all of the features recited by independent Claims 41, 49, 57, and 65, Applicants respectfully submit that these claims and their dependent claims are **nonobvious** over the *prime facie* combinations of references.

In the rejections of Claims 43-48, 51-56, 59-64, and 65-72, the Examiner has cited the court case of *In re Aller* (105 USPQ 233) as holding that the discovery of an optimum or working range involves only routine skill in the art. Applicants respectfully traverse the Examiner's broad application of this holding of the *In re Aller* case. Subsequent court decisions have clarified this holding of *In re Aller* and have limited its scope. These subsequent cases have held that a parameter that is being varied, or optimized, must be *recognized by the prior art references* as having an effect on the desired result or operation of the method or apparatus (see



M.P.E.P. § 2144.05, subsection II.B). In the court's words, the parameter must be recognized by the prior art reference as being a "result-effective" variable. Optimizing a parameter of a prior art device or method is non-obvious *when* the prior art does not recognize the parameter as being "result-effective."

In the case at hand, each of Claims 43-48, 51-56, 59-64, and 65-72 recites a specific relationship between optical output power level  $P_{OUT}$  and cavity length  $L$  which *coordinates* the selections of  $P_{OUT}$  and  $L$  in order to reduce power consumption and increase conversion efficiency. None of the patents to Jeon, Itoh, and Mugino recognizes these relationships (which are the *coordinated* selections of  $P_{OUT}$  and  $L$ ) as being *result-effective* for any desired result, desired operation, or desired purpose. Moreover, none of the patents to Jeon, Itoh, and Mugino recognizes that the cavity length  $L$  is a result-effective variable for achieving minimum power consumption (or maximum conversion efficiency) *at a given optical output power level  $P_{OUT}$* , and none of these patents recognizes that the optical output power level  $P_{OUT}$  is a result-effective variable for achieving minimum power consumption (or maximum conversion efficiency) *for a given cavity length  $L$* . For these reasons, Applicants respectfully submit that the patents to Jeon, Itoh, and Mugino do not provide sufficient basis to support a rejection based on *In Re Aller*.

For the above reasons, Applicants respectfully submit that the *prime facie* combinations of the patents to Jeon, Itoh, and Mugino fail to teach or suggest all the features of independent Claims 41, 49, 57, and 65, and that these independent claims and their dependent claims are non-obvious over the *prime facie* combinations. Accordingly, Applicants respectfully request that this Rejection of Claims 41-72 be withdrawn.

### **New Claims 73-80**

New Claim 73 is dependent upon Claim 39 and recites the features of Claim 29. Applicants respectfully submit that new Claim 73 is supported by original Claim 29 and does not enter new matter.

Each of new Claims 74-80 is dependent upon a respective independent claim, and each recites that the active layer is configured to generate light along at least 1000 microns of the length of the cavity. These claims are supported by FIG. 2 and the description thereof in the specification (pages 15-16) which shows an active layer 3 which spans a length which is greater than or equal to 1000 microns. Accordingly, Applicants respectfully submit that new Claims 74-80 do not enter new matter. In addition, Applicant respectfully submit that this feature is not

shown in the Jeon patent since the active layer in the tapered portion of the Jeon patent does not generate light.

### **CONCLUSION**

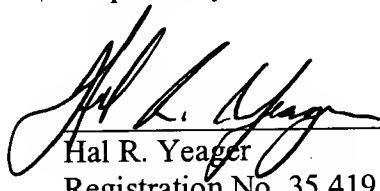
In view of the remarks made above, applicants respectfully submit that the application is in condition for allowance and action to that end is respectfully solicited. If the Examiner should feel that a telephone interview would be productive in resolving issues in the case, he is invited to telephone the undersigned at the number listed below.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned **"Version with markings to show changes made"**.

May 5, 2003

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**“Version with Markings to Show Changes Made”**

Additions are shown by **bold underlining**, deletions are shown between [brackets and in bold type].

**In the Claims:**

*Claims 31, 33, 39, 41, 49, and 57 have been amended as follows:*

31. (Once Amended) A fabrication method for a semiconductor laser apparatus **to be operated at a desired optical output power level from a source of electric drive power, the desired optical output power level being greater than 50 mW, the semiconductor laser apparatus having a semiconductor laminated structure formed on a substrate, the laminated structure including a lower cladding layer, an upper cladding layer, an active layer disposed between the lower and upper cladding layers, a front facet to output the laser beam, a back facet, and a cavity length between the front and back facets, the active layer being configured to generate light such that the apparatus provides optical output power at the front facet in response to the source of electric drive power, the fabrication method** comprising:

acquiring a relationship of [a] the electric drive power **as a function of the cavity length and the optical output power level of the semiconductor laser apparatus, the relationship including cavity lengths greater than 1000  $\mu$ m and optical output power levels greater than 50 mW** [to a range of optical output power over 50mW, for cavity length to be constant as a parameter in a range over 1000  $\mu$ m];

determining a **value of the** cavity length [over 1000  $\mu$ m to be determined on the basis of the] **from the acquired** relationship [acquired by the relationship acquiring step, so] **such** that the electric drive power is vicinal to a minimum **[thereof in correspondence to a desirable]** **for the desired** optical output power **level and such that the value of cavity length is greater than 1000  $\mu$ m, the desired optical power level being greater than 50 mW;** and

forming the semiconductor laser apparatus having **the value of** the cavity length determined by the cavity length determining step.

33. (Once Amended) A fabrication method for a semiconductor laser apparatus to be operated at a desired optical output power level from a source of electric drive power, the desired optical output power level being greater than 50 mW, the semiconductor laser apparatus having a semiconductor laminated structure formed on a substrate, the laminated structure including a lower cladding layer, an upper cladding layer, an active layer disposed between the lower and upper cladding layers, a front facet to output the laser beam, a back facet, and a cavity length between the front and back facets, the active layer being configured to generate light such that the apparatus provides optical output power at the front facet in response to the source of electric drive power, the apparatus having a photoelectric conversion efficiency defined as the ratio of the optical output power to the electric drive power, the fabrication method comprising:

(a) acquiring a relationship of [a] the photoelectric conversion efficiency [to a range of cavity length over 1000  $\mu$ m, for] as a function of the cavity length and the optical output power level of the semiconductor laser apparatus, the relationship including cavity lengths greater than 1000  $\mu$ m and optical output power levels greater than [to be constant as a parameter in a range over] 50 mW;

(b) determining a value of the cavity length [to be determined on the basis of the] from the acquired relationship [acquired by the relationship acquiring step, so] such that the photoelectric conversion efficiency is vicinal to a maximum [thereof in correspondence to a desirable] for the desired optical output power level and such that the value of the cavity length is greater than 1000  $\mu$ m, the desired optical power level being greater than 50 mW;  
and

(c) forming the semiconductor laser apparatus having the value of the cavity length determined by the cavity length determining step.

34. (Once Amended) A fabrication method for a semiconductor laser apparatus according to Claim 33, [further comprising] wherein step (b) comprises:

[determining an approximation expression] obtaining, from the relationship acquired from step (a), an expression between cavity length and optical output power [for making] which describes combinations of cavity lengths and optical output power levels that make the photoelectric conversion efficiency maximal [in correspondence to the

desirable optical output power, on the basis of the relationship acquired by the relationship acquiring step]; and

determining the value of cavity length on the basis of the [approximation] expression.

39. (Once Amended) A fabrication method for a semiconductor laser apparatus to be operated at a desired optical output power level from a source of electric drive power, the semiconductor laser apparatus having a semiconductor laminated structure formed on a substrate, the laminated structure including a lower cladding layer, an upper cladding layer, an active layer disposed between the lower and upper cladding layers, a front facet to output the laser beam, a back facet, and a cavity length between the front and back facets, the upper cladding layer having an impurity carrier concentration, the active layer being configured to generate light such that the apparatus provides optical output power at the front facet in response to the source of electric drive power, the fabrication method comprising:

(a) acquiring a relationship of the electric drive power as a function of [an] the impurity carrier concentration of [an] the upper cladding layer [, for] and the optical output power level of the semiconductor laser apparatus [and cavity length to be constant as parameters];

(b) determining a value of the impurity carrier concentration [to be determined on the basis of] from the acquired relationship [acquired by the relationship acquiring step, so] such that the electric drive power is vicinal to a minimum [in correspondence to a desirable] for the desired optical output power level; and

(c) forming the semiconductor laser apparatus with the upper cladding layer having the impurity carrier concentration set to the [impurity carrier concentration] value determined by the carrier concentration determining step.

41. (Once Amended) A semiconductor laser comprising:

[a resonator cavity having a front facet, a back facet, and a] a semiconductor laminated structure having a substrate, a lower cladding layer, an upper cladding layer, an active layer disposed between the lower and upper cladding layers, a first electrode, a second electrode, a front facet to output the laser beam, a back facet, and a cavity length L between the front and back facets, the active layer being configured to generate light such

**that the apparatus provides optical output power at the front facet in response to a source of electrical power applied to the first and second electrodes, the cavity length L being** in the range of approximately [900] **1000**  $\mu\text{m}$  to approximately 1800  $\mu\text{m}$ ;

**[an active layer disposed within the resonator cavity and being electrically coupled to two electrodes which receive an electrical bias potential from a power supply and which inject electrical current to the active layer;]**

a low reflectance coating disposed on the front facet having a reflectivity of less than approximately 4%;

a high reflectance coating disposed on the back facet and having a reflectivity of more than approximately 80%;

a power supply coupled to said electrodes and applying an amount of power which causes the semiconductor laser to operate with an optical output power level  $P_{\text{OUT}}$  **that is maintained within a range that is** less than or equal to a specified upper bound and greater than or equal to a specified lower bound, the specified upper and lower bounds being based on the cavity length **L**,

the specified lower bound having a value of 50 mW for cavity lengths between approximately 1000  $\mu\text{m}$  and 1380  $\mu\text{m}$ , a value equal to the quantity  $(1\text{mW}) * [(L - 1280\mu\text{m}) / 2\mu\text{m}]$  for cavity lengths of 1380  $\mu\text{m}$  to 1480  $\mu\text{m}$ , a value equal to the quantity  $(1\text{mW}) * [(L - 1260\mu\text{m}) / 2.2\mu\text{m}]$  for cavity lengths of 1480  $\mu\text{m}$  to 1700  $\mu\text{m}$ , a value equal to the quantity  $(2\text{mW}) * [(L - 1600\mu\text{m}) / 1\mu\text{m}]$  for cavity lengths of 1700  $\mu\text{m}$  to 1750  $\mu\text{m}$ , and a value of  $(3\text{mW}) * [(L - 1510\mu\text{m}) / 2\mu\text{m}]$  for cavity lengths of 1750  $\mu\text{m}$  to approximately 1770  $\mu\text{m}$ , and

the specified upper bound having a value equal to the quantity  $(2\text{mW}) * [(L - 950\mu\text{m}) / 1\mu\text{m}]$  for cavity lengths of approximately 1000  $\mu\text{m}$  to 1050  $\mu\text{m}$ , a value equal to the quantity  $(2\text{mW}) * [(L - 750\mu\text{m}) / 3\mu\text{m}]$  for cavity lengths of 1050  $\mu\text{m}$  to 1200  $\mu\text{m}$ , a value equal to the quantity  $(2\text{mW}) * [(L - 450\mu\text{m}) / 5\mu\text{m}]$  for cavity lengths of 1200  $\mu\text{m}$  to 1350  $\mu\text{m}$ , a value equal to the quantity  $(3\text{mW}) * [(L - 150\mu\text{m}) / 10\mu\text{m}]$  for cavity lengths of 1350  $\mu\text{m}$  to 1450  $\mu\text{m}$ , and a value equal to the quantity 390 mW for cavity lengths of 1450  $\mu\text{m}$  to approximately 1770  $\mu\text{m}$ .

49. (Once Amended) A semiconductor laser comprising:

[a resonator cavity having a front facet, a back facet, and a] a semiconductor laminated structure having a substrate, a lower cladding layer, an upper cladding layer, an active layer disposed between the lower and upper cladding layers, a first electrode, a second electrode, a front facet to output the laser beam, a back facet, and a cavity length L between the front and back facets, the active layer being configured to generate light such that the apparatus provides optical output power at the front facet in response to a source of electrical power applied to the first and second electrodes, the cavity length L being in the range of approximately [900] 1000  $\mu\text{m}$  to approximately 1800  $\mu\text{m}$ ;

[an active layer disposed within the resonator cavity;]

a low reflectance coating disposed on the front facet having a reflectivity of less than approximately 4%;

a high reflectance coating disposed on the back facet and having a reflectivity of more than approximately 80%;

an optical output power level  $P_{\text{OUT}}$  maintained within a range that is less than or equal to a specified upper bound and greater than or equal to a specified lower bound, the specified upper and lower bounds being based on the cavity length L,

the specified lower bound having a value of 50 mW for cavity lengths between approximately 1000  $\mu\text{m}$  and 1380  $\mu\text{m}$ , a value equal to the quantity  $(1\text{mW}) * [(L - 1280 \mu\text{m}) / 2\mu\text{m}]$  for cavity lengths of 1380  $\mu\text{m}$  to 1480  $\mu\text{m}$ , a value equal to the quantity  $(1\text{mW}) * [(L - 1260 \mu\text{m}) / 2.2\mu\text{m}]$  for cavity lengths of 1480  $\mu\text{m}$  to 1700  $\mu\text{m}$ , a value equal to the quantity  $(2\text{mW}) * [(L - 1600 \mu\text{m}) / 1\mu\text{m}]$  for cavity lengths of 1700  $\mu\text{m}$  to 1750  $\mu\text{m}$ , and a value of  $(3\text{mW}) * [(L - 1510 \mu\text{m}) / 2\mu\text{m}]$  for cavity lengths of 1750  $\mu\text{m}$  to approximately 1770  $\mu\text{m}$ , and

the specified upper bound having a value equal to the quantity  $(2\text{mW}) * [(L - 950 \mu\text{m}) / 1\mu\text{m}]$  for cavity lengths of approximately 1000  $\mu\text{m}$  to 1050  $\mu\text{m}$ , a value equal to the quantity  $(2\text{mW}) * [(L - 750 \mu\text{m}) / 3\mu\text{m}]$  for cavity lengths of 1050  $\mu\text{m}$  to 1200  $\mu\text{m}$ , a value equal to the quantity  $(2\text{mW}) * [(L - 450 \mu\text{m}) / 5\mu\text{m}]$  for cavity lengths of 1200  $\mu\text{m}$  to 1350  $\mu\text{m}$ , a value equal to the quantity  $(3\text{mW}) * [(L - 150 \mu\text{m}) / 10\mu\text{m}]$  for cavity lengths of 1350  $\mu\text{m}$  to 1450  $\mu\text{m}$ , and a value equal to the quantity 390 mW for cavity lengths of 1450  $\mu\text{m}$  to approximately 1770  $\mu\text{m}$ .

57. (Once Amended) A method of [operating] increasing the photoelectric conversion efficiency of a semiconductor laser, the semiconductor laser including a semiconductor laminated structure having a substrate, a lower cladding layer, an upper cladding layer, an active layer disposed between the lower and upper cladding layers, a first electrode, a second electrode, a front facet to output the laser beam, a back facet, and a cavity length L between the front and back facets, the active layer being configured to generate light such that the apparatus provides optical output power at the front facet in response to a source of electrical power applied to the first and second electrodes, [a resonator cavity having a front facet, a back facet, and a] the cavity length L [between facets] being in the range of approximately [900] 1000  $\mu\text{m}$  to approximately 1800  $\mu\text{m}$ , the semiconductor laser further including [an active layer disposed within the resonator cavity,] a low reflectance coating disposed on the front facet having a reflectivity of less than approximately 4%, and a high reflectance coating disposed on the back facet and having a reflectivity of more than approximately 80%, said method comprising the step of:

operating the semiconductor laser at an optical output power level  $P_{\text{OUT}}$  which is less than or equal to a specified upper bound and which is greater than or equal to a specified lower bound [based on the cavity length], the specified upper and lower bounds being based on the cavity length L,

the specified lower bound having a value of 50 mW for cavity lengths between approximately 1000  $\mu\text{m}$  and 1380  $\mu\text{m}$ , a value equal to the quantity  $(1\text{mW}) * [(L - 1280\mu\text{m}) / 2\mu\text{m}]$  for cavity lengths of 1380  $\mu\text{m}$  to 1480  $\mu\text{m}$ , a value equal to the quantity  $(1\text{mW}) * [(L - 1260\mu\text{m}) / 2.2\mu\text{m}]$  for cavity lengths of 1480  $\mu\text{m}$  to 1700  $\mu\text{m}$ , a value equal to the quantity  $(2\text{mW}) * [(L - 1600\mu\text{m}) / 1\mu\text{m}]$  for cavity lengths of 1700  $\mu\text{m}$  to 1750  $\mu\text{m}$ , and a value of  $(3\text{mW}) * [(L - 1510\mu\text{m}) / 2\mu\text{m}]$  for cavity lengths of 1750  $\mu\text{m}$  to approximately 1770  $\mu\text{m}$ , and

the specified upper bound having a value equal to the quantity  $(2\text{mW}) * [(L - 950\mu\text{m}) / 1\mu\text{m}]$  for cavity lengths of approximately 1000  $\mu\text{m}$  to 1050  $\mu\text{m}$ , a value equal to the quantity  $(2\text{mW}) * [(L - 750\mu\text{m}) / 3\mu\text{m}]$  for cavity lengths of 1050  $\mu\text{m}$  to 1200  $\mu\text{m}$ , a value equal to the quantity  $(2\text{mW}) * [(L - 450\mu\text{m}) / 5\mu\text{m}]$  for cavity lengths of 1200  $\mu\text{m}$  to 1350  $\mu\text{m}$ , a value equal to the quantity  $(3\text{mW}) * [(L - 150\mu\text{m}) / 10\mu\text{m}]$  for cavity lengths of 1350  $\mu\text{m}$  to 1450  $\mu\text{m}$ , and a value equal to the quantity 390 mW for cavity lengths of 1450  $\mu\text{m}$  to approximately 1770  $\mu\text{m}$ .



65. A method of **[selecting the cavity length of] forming a** semiconductor laser to provide reduced power consumption or increased photoelectric conversion efficiency for a selected output power **level**  $P_{OUT}$  in the range between approximately 50mW and approximately 400 mW, the semiconductor laser including **[a resonator cavity having a front facet, a back facet, an active layer disposed within the resonator cavity] a semiconductor laminated structure having a substrate, a lower cladding layer, an upper cladding layer, an active layer disposed between the lower and upper cladding layers, a first electrode, a second electrode, a front facet to output the laser beam, a back facet, and a cavity length between the front and back facets, the active layer being configured to generate light such that the apparatus provides optical output power at the front facet in response to a source of electrical power applied to the first and second electrodes, the semiconductor laser further including** a low reflectance coating disposed on the front facet having a reflectivity of less than approximately 4%, and a high reflectance coating disposed on the back facet and having a reflectivity of more than approximately 80%, **[the cavity length being between the front and back facets,]** said method comprising:

selecting the cavity length to be within one of four ranges depending upon the value of the selected output power **level**  $P_{OUT}$ ,

the first range being between approximately 1000  $\mu\text{m}$  and approximately  $\{2\mu\text{m}*(P_{OUT}/1\text{mW}) + 1280 \mu\text{m}\}$  for values of  $P_{OUT}$  between approximately 50 mW and approximately 100 mW,

the second range being between approximately  $\{1\mu\text{m}*(P_{OUT}/2\text{mW}) + 950\mu\text{m}\}$  and approximately  $\{2.2\mu\text{m}*(P_{OUT}/1\text{mW}) + 1260 \mu\text{m}\}$  for values of  $P_{OUT}$  between approximately 100 mW and approximately 200 mW,

the third range being between approximately  $\{3\mu\text{m}*(P_{OUT}/2\text{mW}) + 750\mu\text{m}\}$  and approximately  $\{1\mu\text{m}*(P_{OUT}/2\text{mW}) + 1600 \mu\text{m}\}$  for values of  $P_{OUT}$  between approximately 200 mW and approximately 300 mW, and

the fourth range being between approximately  $\{5\mu\text{m}*(P_{OUT}/2\text{mW}) + 450 \mu\text{m}\}$  and approximately 1750  $\mu\text{m}$  for values of  $P_{OUT}$  between approximately 300 mW and approximately 360 mW, and

the fifth range being between approximately  $\{10\mu\text{m}*(P_{OUT}/3\text{mW}) + 150 \mu\text{m}\}$  and approximately  $\{2\mu\text{m}*(P_{OUT}/3\text{mW}) + 1510 \mu\text{m}\}$  for values of  $P_{OUT}$  between approximately 360 mW and approximately 390 mW.